R & D facts

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Underground Mine Water for Heating and Cooling Using Geothermal Heat Pump Systems

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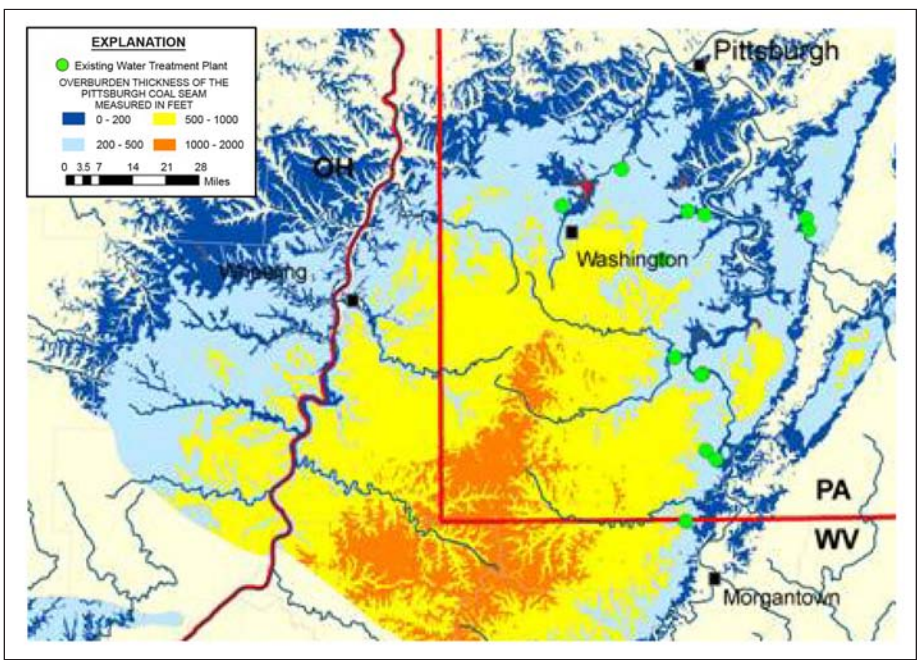
Introduction

Many mining regions in the United States contain extensive areas of flooded underground mines. The water within these mines represents a significant and widespread opportunity for extracting low-grade, geothermal energy. Based on current energy prices, geothermal heat pump systems using mine water could reduce the annual costs for heating over 80 percent compared to conventional heating methods (natural gas or heating oil). These same systems could reduce annual cooling costs by up to 50 percent over standard air conditioning in many areas of the country.

Potential of the Pittsburgh Coal Seam Mine Pool for Heating and Cooling

A significant volume of the Pittsburgh coal seam in Pennsylvania, West Virginia and Ohio is currently flooded. The availability of underground mine water in the Appalachian coal region is very widespread. Approximately 5,000 km^2 of the Pittsburgh coal seam in the northern portion of the Appalachian coal fields are currently flooded.



The mine water is easily accessible and maintains a constant temperature of 10 to 13 °C. The total volume of water estimated to be stored in the Pittsburgh coal seam is 5.15 x 1012 liters with about 4 percent of this volume being discharged at the surface totaling about 2.0 x 1011 liters per year. This current amount of discharged water could potentially be used to heat and cool up to 4 million m^2 of interior space, roughly equivalent to 20,000 homes. As the mines in this area continue to fill with water and with new voids being created by active mining, the volume of stored and discharged water from these underground mines will continue to increase into the future.

Cost Effectiveness of Geothermal Heat Pump Systems

The cost effectiveness of geothermal heat pump systems for heating is directly related to the cost of electricity (to operate the heat pump) compared to the cost of the other conventional fuels – natural gas, heating oil and propane. The cost effectiveness for geothermal heating is at its highest in the past 50 years.

Cost for one million Btu of heat using geothermal heat pump technology compared to conventional heating technology using actual energy costs in the southwestern Pennsylvania area.

Energy source	Formula for Cost Per 106 Btu	US$/106 Btu*
Propane	(11.1 x cost/gallon) / efficiency	32.11
Electrical Resistance	293 x cost/kWh	20.80
Fuel Oil	(7.25 x cost/gallon) / efficiency	20.28
Natural Gas	(970 x cost/cubic feet) / efficiency	20.81
Geothermal Heat Pump (COP = 3.0)	(293 x cost/kWh) / COP	6.93
Geothermal Heat Pump (COP = 3.5)	(293 x cost/kWh) / COP	5.94
Geothermal Heat Pump (COP = 4.0)	(293 x cost/kWh) / COP	5.20
Geothermal Heat Pump (COP = 6.0)	(293 x cost/kWh) / COP	3.47

* *Cost of fuels and electricity were based on actual delivered cost to the Pittsburgh, Pennsylvania area during the winter of 2005/2006. Propane = $2.43/gallon, electricity = $0.071/kWh, fuel oil = $2.35/gallon and natural gas = $0.01802/cubic feet. Furnaces using propane, natural gas or fuel oil were assumed to be moderately efficient (84 percent). Most geothermal heat pumps operate at a coefficient of performance (COP) between 3.0 and 4.0 with values as high as 6.0 reported in the literature.*

Summary and Conclusions

Use of underground mine water in geothermal heat pumps could be extremely cost effective, particularly at existing mine water treatment sites where the mine water is already being pumped and treated. Operational costs are much lower than that of conventional heating and cooling options. Costs per unit of heat for geothermal heat pumps using underground mine water may be less than 17 percent of the costs incurred using fuel oil, natural gas or propane. Cooling costs using mine water and geothermal heat pumps should be less than 50 percent of the costs associated with conventional air conditioning systems. Because most mines are currently filling, the volumes of discharged and stored water will continue to increase in the future. Research is needed to demonstrate and develop this extremely valuable resource.

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